

## **BUILDING MARITIME DATA HUB BY USING THE ARDUINO IoT PLATFORM**

Assistant Professor PhD Yordan A. Sivkov

Nikola Vaptsarov Naval Academy  
73 Vasil Drumev str., Varna, Bulgaria  
e-mail: [jsivkov@naval-acad.bg](mailto:jsivkov@naval-acad.bg)

**Abstract:** The study of marine resources, the status of water bodies and others is directly related to the measurement of a large number of parameters and further processed individually or as dependent on each other. Failing due to objective reasons / lack of power, lack of sufficient computing resources, excessive appreciation in the presence of expertise in place, the need to obtain data from several points split in space and sometimes in time / to perform data processing in the place of collection is implemented different platforms that have several types of sensors. This requires the use of a single system for data collection and consolidation and unified message for transmission to the expert control system.

With the integration of data from different types of sensors must be considered interfaces and standards used in equipment platform to collect data and in accordance with world standards in the production of electronic equipment for the marine industry is seen dominance of standard NMEA 0183 -HS and NMEA 2000 communication of these sensors and the system for collecting information.

In some cases used sensors are not realized by providing output NMEA standard, which requires a transformative device that interface to NMEA. This approach allows for the implementation of each sensor network used in shipping than one side. On the other allows for the realization of a system for collecting and processing data, which have unification of input interfaces to reduce the cost and scalability.

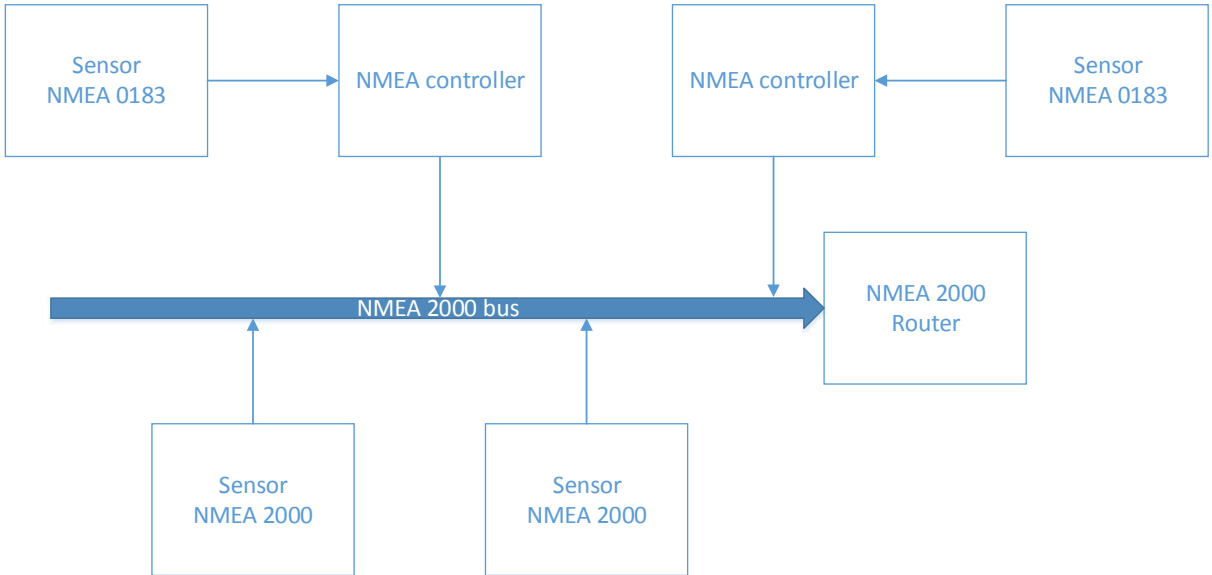
For transformation of the interface need a device with the ability to customize the algorithm of conversion depending on the input data, such as configuration must allow dynamic change in the course of work. Most suitable for this purpose is a module based on a microprocessor that supports current market sensor interface and sufficient processing power to perform the conversion without added lag.

The proposed solution gives flexibility when working with different types of sensors, as well as the ability to process only the software package for compatibility with the different NMEA standards. Expansion of the set of sensors combined with the ability to use the created hub for all available and incoming protocols, as well as the ability to operate independently, as a system for collecting, processing, storing and transmitting received data shows the adequacy of the use of modern Arduino platforms.

**Keywords:** NMEA, sensor data processing, unify data message, IoT, Arduino

**Introduction**

The study of marine resources, the status of water bodies and others is directly related to the measurement of a large number of parameters and further processed individually or as dependent on each other. Failing due to objective reasons / lack of power, lack of sufficient computing resources, excessive appreciation in the presence of expertise in place, the need to obtain data from several points split in space and sometimes in time / to perform data processing in the place of collection is implemented different platforms that have several types of sensors. This requires the use of a single system for data collection and consolidation and unified message for transmission to the expert control system (Tsvetkov, 2013).

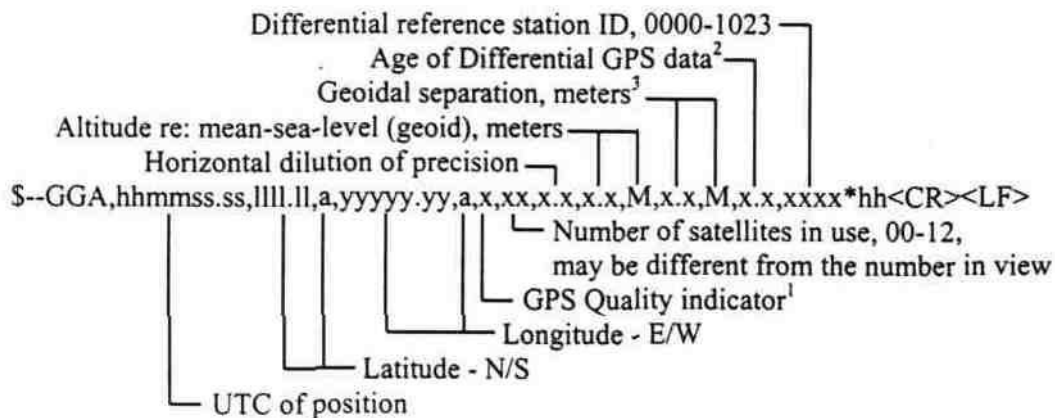


**Figure 1** NMEA 2000 sensor network

With the integration of data from different types of sensors must be considered interfaces and standards used in equipment platform to collect data and in accordance with world standards in the production of electronic equipment for the marine industry is seen dominance of

standard NMEA 0183 -HS and NMEA 2000 communication of these sensors and the system for collecting information (NMEA, 2008) (Association, 2008).

The NMEA 2000 standard implements a network of sensors communicating over a common bus and router to the control system or NMEA 0183 by using transient converters and re-switching to the joint network (Figure 1) (NMEA, 2008) (Association, 2008)).



**Figure 2** NMEA GGA message

The NMEA standard also provides for a special mode of transmission of information in a formalized message for each type of data from different sensors. For example, over 10 different messages are available for the GPS receiver, which starting with the NMEA standard "\$" and using ASCII characters, such as the Global Positioning System Fix Data (GGA) (Figure 2) (Luft, et al., 2002) (NMEA, 2008) (Tsvetkov, 2013) (Tsvetkov, M., Nikolov, Zh., 2013).

The unification of the output data allows for the implementation of a network of sensors from different manufacturers (Dimitrov, 2015) and adding additional sensors at the only requirement to satisfy the hardware parameters and standards for the transmission of messages.

### Methods and results

In some cases, the used sensors are not implemented with a NMEA standard output that requires a device that converts the specified interface to the NMEA. Through this approach, it is possible to introduce each sensor in a network used in shipping on the one hand. On the other hand, it is possible to implement a system for data collection and processing, in which there is uniformity of the input interfaces in order to reduce the cost and scalability.

For transformation of the interface need a device with the ability to customize the algorithm of conversion depending on the input data, such as configuration must allow dynamic change in the workflow. The most suitable for this purpose is a microprocessor-based module supporting current market interfaces and sufficient computational power to perform the conversion without adding lag.

When converting data from the most commonly used sensors such as temperature, pressure, direction, voltage, speed, rate, position, salinity, etc. A conversion rate of between hundreds of milliseconds to a few seconds is required, depending on the rate of process change, the speed of data conversion from the sensor, and the need for up-to-date data to the control system. At operating speeds above 8 MHz (and generally over 50 MHz) in modern microcontroller systems and performing instructions within one generator stroke, the maximum data transmission time in the communications network is within one millisecond and is mainly determined of the sensor conversion rate. The latter allows for the use of a microcontroller system for data transmission from several sensors, which would reduce the financial and the logistic costs (like a consumption, repairability and installation space).

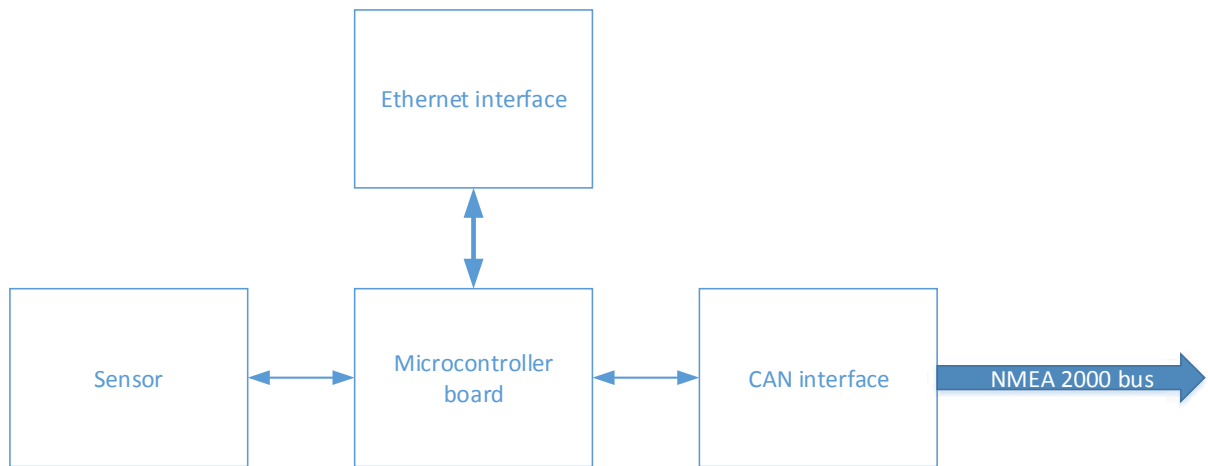
The implementation of the approach is based on the following initial requirements:

- low cost by using widely applicable microcontroller systems;
- a short time to add a new sensor;
- possibility of reconfiguring the system in the process of changing the sensor type;
- low consumption and small size;
- To have ability to scale the capabilities developed by increasing the computing and interface resources.

The system is based on a block diagram shown on Figure 3 and consisting of a sensor communicating with a given protocol (digital or analogue) with a microcontroller. It receives and processes the information by converting the input value into the corresponding NMEA standard and transmits the received message via the CAN interface NMEA network. The Ethernet interface is used to configure the reader settings from the sensor and the transmitted message to the network.

This set of requirements is fully covered by one of the leading platforms for the development of the Internet of Things - Arduino.

The platform provides a set of the most commonly used sensor interfaces - I2C, SPI, USART, USB and analog-to-digital converter, which helps to achieve low cost. The absence of an interface is compensated by the availability of a wide variety of interface boards that provide 100% coverage of currently available communication protocols with external sensors.



**Figure 3** NMEA microcontroller interface

Using the unified programming language with a wide range of library functions available and the large set of systems running under it provide the required capabilities for a short time to develop and scalable resources. The time to switch from an eight-bit, 16 MHz microcontroller to a state-of-the-art Cortex architecture, a 32-bit 160 MHz microcontroller with much larger computing resources, will take several minutes and can be done locally. Additionally, the unified standard used when making the boards may not require replacement of the whole block but only an element of it.

## Sensor configuration

Configure the sensor connected to the platform ID 375-5568-251

NMEA configuration

**Select NMEA message**

SMTW

**NMEA 2000 speed**

Sensor information

**Name:**

**Type of sensor**

Temperature

**Data type**

digital

analog

Sensor interface (only for digital)

UART

I2C

SPI

SPI

QWI

TWI

Write configuration
Clear

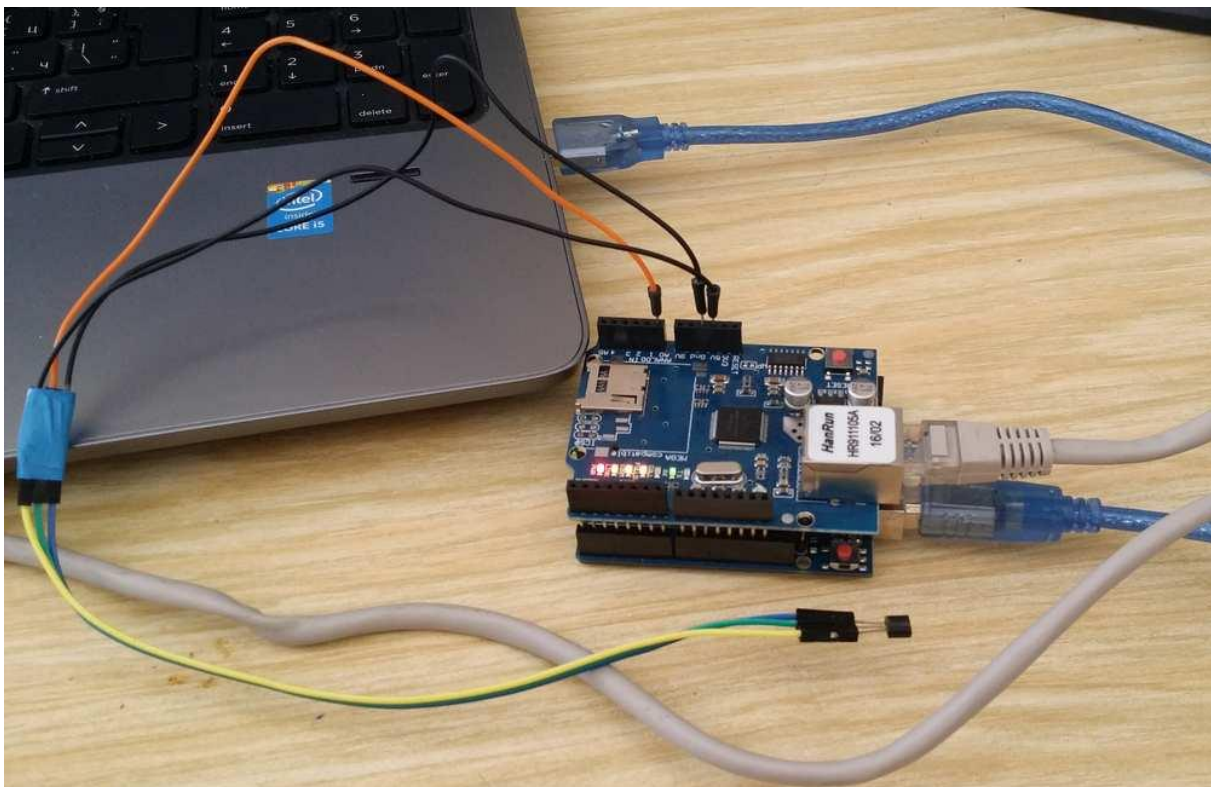
**Figure 4** Ethernet configuration page

The possibility of reconfiguration during operation is provided by an additional Ethernet interface that provides communication via a website (Figure 4). All the necessary settings are

intuitively done on the site and recorded in the microcontroller system, which changes its settings. Reconfiguration takes place in several steps:

- Selection of interface type for sensor operation;
- Interface characteristics;
- Characteristics of the NMEA message.

To verify the approach, an experimental setup has been developed using an analogue temperature sensor, the Arduino Uno platform with additional expansion boards for Ethernet interface and CAN interface (Figure 5).



**Figure 5** An experimental set-up with IoT platform

The Arduino language was used to develop the software package by real-time transformation of the data obtained from the analog sensor in the NMEA format representing the air temperature and transmitting them to the NMEA 2000 network using a message \$--MTA (Figure 6). Configuration of the converter is done through a web interface that providing adjustment of the following parameters:

- characteristics of the network interface;
- time of data transmission from the sensor;
- synchronization source;
- time and format for recording the sensor data;

- characteristics of the sensor data displayed in table and graphical form;
- features for tuning the data transmission via an Ethernet interface to an collect and processing system;
- adding additional sensors (optional);
- logic of the sensor data transmission - transmission at a certain interval or at change;
- set a time interval for transmission in each channel – NMEA200 and Ethernet.

```
$--MTA, x.x, C *hh <CR><LR>
| Temperature, degrees C
```

**Figure 6** NMEA Temperature message

In the so-constructed node provided for the conversion of data from analog sensors, transmitted to the NMEA 2000 network, data retention for a certain period, and the transmission of data in an alternate network built on Ethernet, which facilitates the integration of that approach in a new generation of OneNet NMEA networks.

## Conclusion

The construction of an intermediate system to convert data from any sensor to the NMEA 2000 standard allows the addition of a large number of inaccessible sensors. The application of widely used microcontroller systems with a large community enables the cost reduction of the device and the use of the available library functions for sensors, which in turn speeds up the process of integration of new sensors.

Next steps to develop communication protocols for data exchange in ship information systems is to switch to a network protocol that provides greater capabilities, from both data rate and communication security, longer distances and broader applications in practice. Such a protocol can be Ethernet using wired and wireless communication.

The proposed solution gives flexibility when working with different types of sensors, as well as the ability to process only the software package for compatibility with the different NMEA standards. Expansion of the set of sensors combined with the ability to use the created hub for all available and incoming protocols, as well as the ability to operate independently, as a system for collecting, processing, storing and transmitting received data shows the adequacy of the use of modern Arduino platforms.

## Referances

- Association, N., 2008. *NMEA 0183 - Standard for Interfacing Marine Electronic Devices v. 4*. s.l.:International Marine Electronics Association.
- Dimitrov, G., 2015. *IP Switching and Modern communications*. Varna, e-Navigation & e-Maritime Black Sea - East Med 2015.
- Krile S, K. D. D. F., 2013. NMEA communication standard for shipboard data architecture. 60(3-4).
- Luft, L. A., Anderson, L. & Cassidy, F., 2002. NMEA 2000® Marine Network Standard. *Institute of Navigation's 2002 National Technical Meeting*, 30 1.
- NMEA, 2008. *NMEA 2000® Marine Network Standard*, s.l.: NMEA.
- Tsvetkov, M., Nikolov, Zh., 2013. *Using MATLAB for Global Navigation Satellite System (GNSS) surveys*. Constanta, CMU.
- Tsvetkov, M., 2013. Software module for GNSS Navstar radioephemeris processing. *Journal of Marine Technology and Enviroment*, V(2), pp. 101-109.